Measurement of Upper Atmospheric Ionization and Wind with a Combined Payload

Second Quarterly Report

Covering the Period
1 November 1964 - 31 January 1965

Contract No. NASw-1083

Project Managers

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Measurement of Upper Atmospheric Ionization and Winds with a Combined Payload

INTRODUCTION

At the start of this reporting period the first of the two field trips to Fort Churchill required by the contract was in progress. This trip was terminated on 15 November 1964 after only one of the scheduled four vehicles had been launched. Although that rocket (Nike Apache 14.197) was successfully launched and data on wind and electron density obtained, the primary objective of getting a sequence of measurements during a single night was not attained.

During the Quarter a GCA Technical Report "Canister for Producing TMA Trails in the Upper Atmosphere" by A. Corman and N. J. Guarino was prepared and is now being published. This gives a detailed account of an earlier phase of the present contract.

Analysis of the data from the rocket flights of this project (14.194, 14.195, and 14.197) is continuing. The data is being supplemented by a re-evaluation of data from five earlier pairs of flights, listed in Table 1. The time interval between the two flights of each pair in the 1962 series detracts from the value, but current evidence indicates that the wind structure does not change rapidly enough to invalidate the data.

Table 1: Correlated Electron Density and Wind Observations

Date	Electron Density Profile		Wind Profile		ΔT
	Vehicle	Launch	Vehicle	Launch	minutes
7 November 1962	10.99	0525	14.16	0553	28
30 November 1962	10.108	0557	14.17	0615	18
5 December 1962	10.109	1700	14.18	1716	16
15 July 1964	14.144	0300	14.51	0305	5
	14.145	0420	14.52	0406	-14

Note: All launches from Wallops Island, Virginia. Launch is Eastern Standard Time.

One of the more interesting results of the flights of the combined payloads is the effect on the DC probe and the telemetry system of releasing sodium vapor (on 14.194 and 14.197) or TMA (on 14.195). This indicates a preference in future flights for TMA rather than sodium.

FIELD TRIP TO FORT CHURCHILL

Four Nike Apache test vehicles were to be launched according to the following schedule:

Test Vehicle	Date	Time
NASA 14.196 CA	28 October 1964	Eve. Twilight
NASA 14.197 CA	28 October 1964	2200 CST
NASA 14.198 CA	29 October 1964	0200 CST
NASA 14.199 CA	29 October 1964	Morning Twilight

As stated in the Operations Directive (153) "due to stringent weather requirements, it may be necessary to reschedule these firings on a day-to-day basis until satisfactory conditions for firing exists." Table 2 is a brief summary of the day-to-day status of this experiment during 28 October-15 November 1964.

During this nineteen day period, with the exception of four days when another experiment took precedence, both Range (Pan-American Airways) and User (GCA Corporation) personnel were on a continuous stand-by status. The postponement of the three remaining firings in this series was caused

Table 2: Summary of Field Trip

Date	Range Status	User Status	Sky	Sunshire Hours	Comments
Oct. 28 1200 CST	Schedule PM Twilight	On Site	Broken	6.8	First Try at Four Shot Series Cancel at T-5 Min.
Oct. 29 30	Schedule PM Twilight	On Site	Scattered Broken	1.0	Cancel at T-5 Min.
Oct. 30 31	Stand By	On Site	Overcast	0.0	Weather Check
Oct. 31 Nov. 1	Schedule Night Shot	On Site	Clear Broken	3.5	Successful Shot 2400 Three Shot Series Attempted Cancel at 0300
Nov. 1 2	Stand By	On Site	Overcast	0.0	Men in From Sites on Monday Morning
Nov. 2 3	Javelin	Base	Rain Overcast	0.0	
Nov. 3 4	Javelin	Base	Snow Overcast	0.0	
Nov. 4 5	Javelin	Base	Snow Overcast	0.0	
Nov. 5 6	Javelin	Base	Broken	0.0	
Nov. 6 7	Stand By	Stand By	Rain Overcast	0.0	Weather Check
Nov. 7 8	Stand By	On Site	Snow Overcast	0.0	Weather Check
Nov. 8 9	Stand By	On Site	Snow Overcast	0.3	Weather Check

Date	Range Status	User Status	Sky	Sunshire Hours	Comments
Nov. 9			Obscured		
10	Stand By	On Site	Fog	4.3	Weather Check
Nov. 10			Obscured		
11	Stand By	On Site	Fog	0.0	Weather Check
Nov. 11					
12	Stand By	On Site	Broken	0.0	Weather Check
Nov. 12	Schedule				Try for Two Shot Series (TMA) Cancel T-25 Min 0400
13	Night Shot	On Site	Broken	-	
Nov. 13	Schedule		Scattered		Try for Two Shot Series (TMA) Cancel T-25 Min 0300
14	Night Shot	On Site	Broken	-	
Nov. 14	Stand By				
15		On Site	Broken	-	Weather Check
Nov. 15					
16	Stand By	Base	Overcast	-	Weather Check

by unsatisfactory weather at Churchill and the outlying cameras sites. A general picture of the weather at the main base is given in the columns labeled sky and sunshine hours in Table 2. More severe conditions sometimes existed at the outlying sites.

The meteorological forecasts provided by the Range were compromised because of the great distances from Churchill of the weather observation sites available to the Meteorological Office; the weather observations from the closer-in network of the GCA Corporation camera sites were a prime input to the forecast. Accordingly, a schedule was set up which consisted of radio contact with the camera sites at 1300 hours each day. The forecaster then used the input to provide a complete forecast to the User at 1430. If any hint of improvement or change was apparent this procedure was followed again at 1600 and at 2100 and the decision to pick up the count made accordingly. During a countdown continuous contact was maintained with the sites.

In reviewing the nineteen day period depicted in Table 2 it is seen that during the first four days on the Range (October 28-31) conditions were such that there was at least a chance of completing a four shot series in one night. The importance of a four shot series that would provide additional information on the quasi-periodic nature of the winds was being stressed at this time, i.e., if the first twilight was not suitable then the remainder of the series for that particular night would be cancelled.

On the 28th and 29th, conditions were marginal and the countdown went to T-5 minutes before cancellation. The count was not started on the 30th because chance of clearing was very unlikely.

During the day of October 31 a strong northwest wind was clearing the region of cloud cover. The first twilight shot was cancelled due to high winds but improving conditions plus an optimistic forecast issued at 1630 for the remainder of the night, resulted in the scheduling of a three shot series commencing at midnight. The first shot (sodium) was fired successfully at 2400 CST. An unpredicted shift in the wind, first detected at the southern most camera site, resulted in all sites being overcast by 0300 and forced cancellation of the night and the following twilight shot. The night of November 1 was overcast and freezing rain developed.

The Range was not available for the project (November 2 through November 6) although weather history shows that conditions were not satisfactory for this project in any event.

From November 6 through November 11, both Range and User personnel were on continuous stand-by although no countdowns were started. It was decided that because of the highly unlikely chance of getting an entire night, or most of a night clear, that a night and twilight shot separated by four hours would be attempted if possible. This required all personnel to be on stand-by status and to conduct weather checks until at least 2200 hours.

On November 12 because of improving weather during the night, a night shot was scheduled for 0300 on November 13 to be followed at morning twilight by a second shot. This series was held at T-25 minutes until 0400 and cancelled when there was obviously a deteriorating weather condition.

The same procedure was followed on the night of November 13-14 with the count held at T-5 minutes until 0300. On the nights of the 14th and 15th, weather checks were made until 2300 hours. On Monday, November 16, the camera operations were brought in by helicopter from the isolated sites just in advance of a blizzard.

Camera sites at Seal River, Belcher, Twin Lakes, and launch were reporting clear skies in the expected field of view at the time of firing of Nike Apache 14.197. However, the actual azimuth followed by the rocket was about 30° different from that predicted and the trail was not formed in the expected position. At Seal River, the trail was obscured by clouds in the new direction and other sites were partially affected. Thus, the data are minimal and the altitude range and accuracy of the wind determination were reduced. The winds shown in Figures 1a and 1b were determined at discrete points corresponding to discernible features on the trail between 95 and 125 km.

At about 112 km, the wind speed was over 300 m/sec, the greatest speed ever observed from a vapor trail although winds over 200 m/sec have previously been observed at Fort Churchill. It may be significant that such

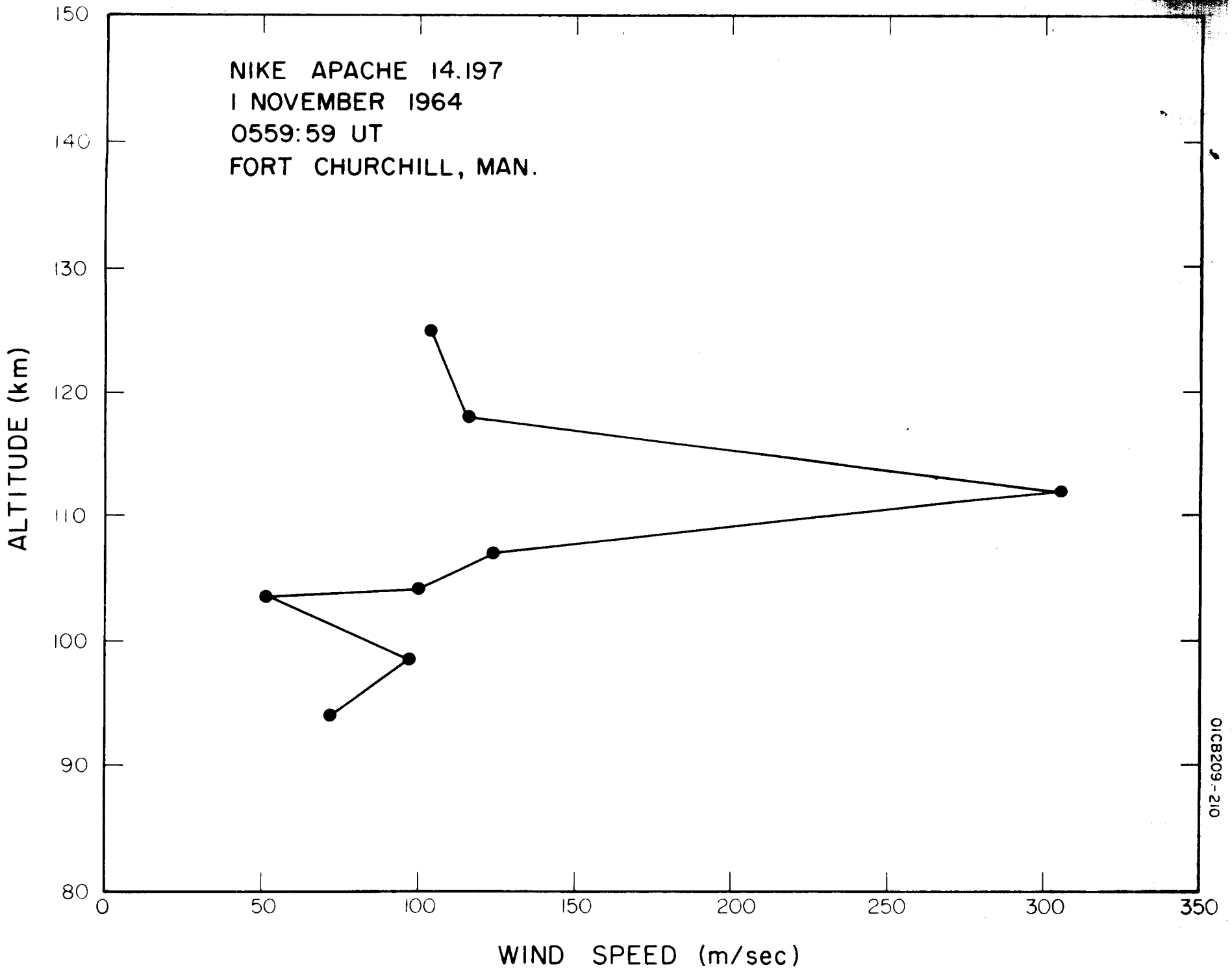
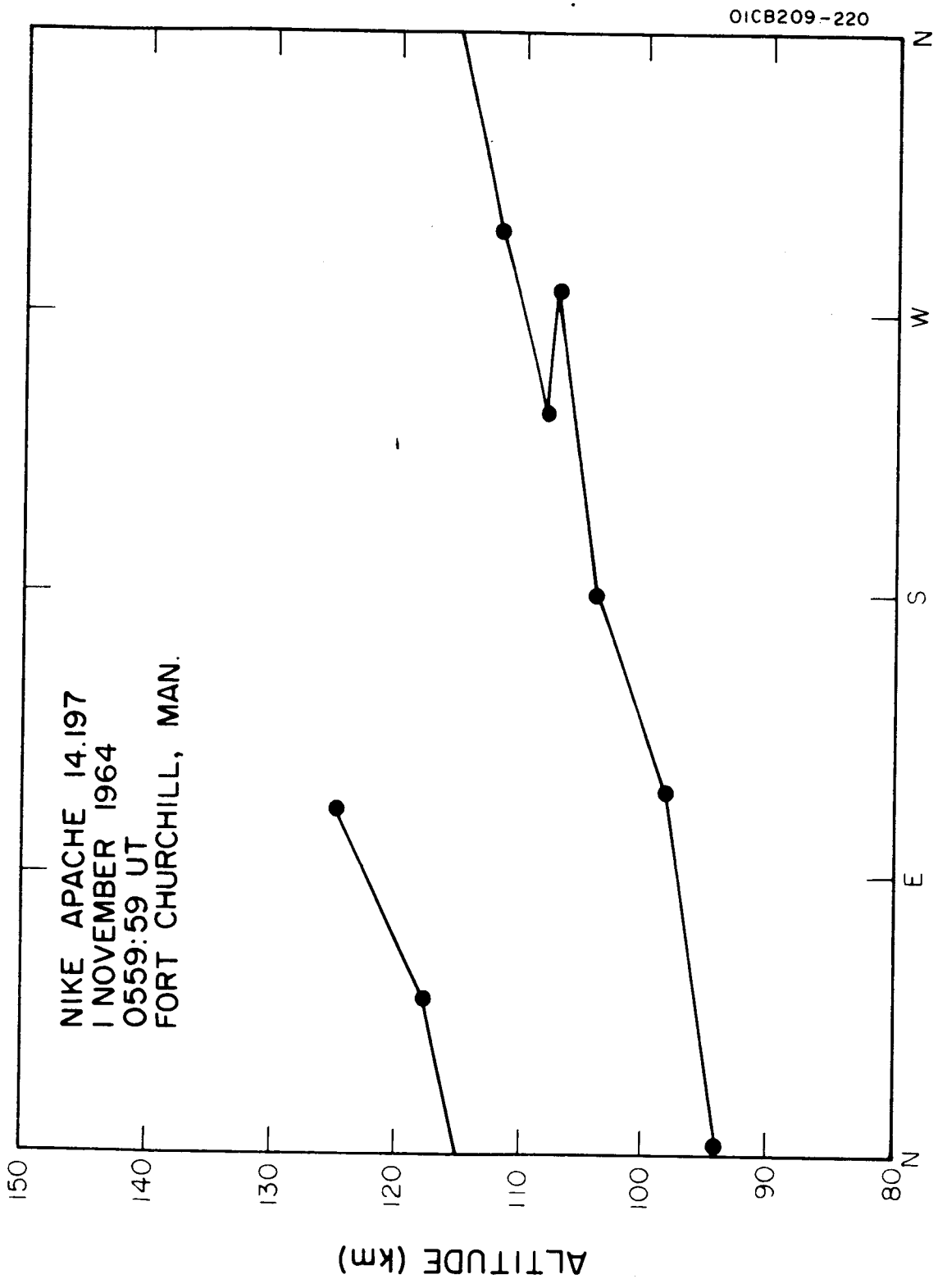


Figure 1a

Wind velocity data from Nike Apache 14.197.



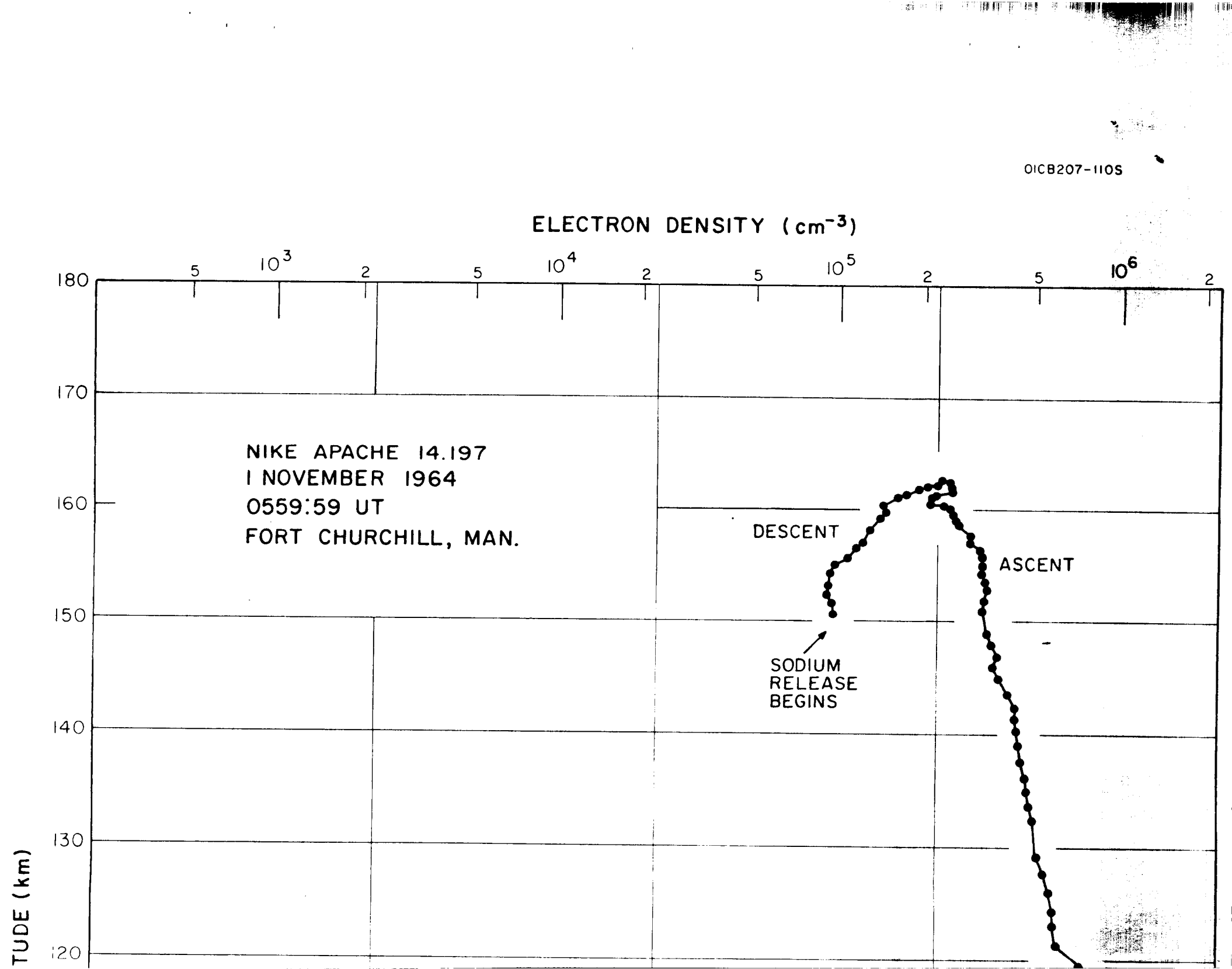
Wind direction data from Nike Apache 14.197.

Figure 1b

high speeds occurred during an intense aurora. Various theories have considered the relationship of wind and auroral features. Recently Boström* has developed models of auroral electrojets which are currents flowing in auroral arcs and are proposed as an explanation of the local magnetic disturbances frequently observed during aurora. He assumed that the currents may be driven either by ionospheric winds or by electric fields in the magnetosphere. He calculated that wind speeds of 440 m/sec are required and concluded that this speed appears unreasonably high when compared with observed speeds of 100-150 m/sec. However, our observation of 300 m/sec requires a reconsideration of the relationship of aurora features and winds.

The electron density profile obtained from Nike Apache 14.197 up to the time that the sodium release began is shown in Figure 2. During the night there was considerable auroral activity which accounts for the unusually high electron density. The maximum electron density is nearly $8 \times 10^5 cm^{-3}$ occurring at 119.5 km. For comparison it may be noted that the normal daytime electron density at this altitude at Wallops Island, Virginia, is about 1×10^5 cm^{-3}. Relatively little structure is present although minor peaks may be noted at 97.5, 103.5 and 119.5 km. The ascent and descent profiles are significantly different and indicate that considerable horizontal gradients of electron density are present.

*Boström, Rolf. A Model of the Auroral Electrojets, J.G.R., 69, No. 23, pp. 4983, December 1964.


ELECTRON DENSITY (cm^{-3})
5
10^3
2
5
10^4
2
5
10^5
2
5
10^6
2
180
170
160
150
140
130
120
NIKE APACHE 14.197
1 NOVEMBER 1964
0559:59 UT
FORT CHURCHILL, MAN.
DESCENT
ASCENT
SODIUM
RELEASE
BEGINS
TUDE (km)

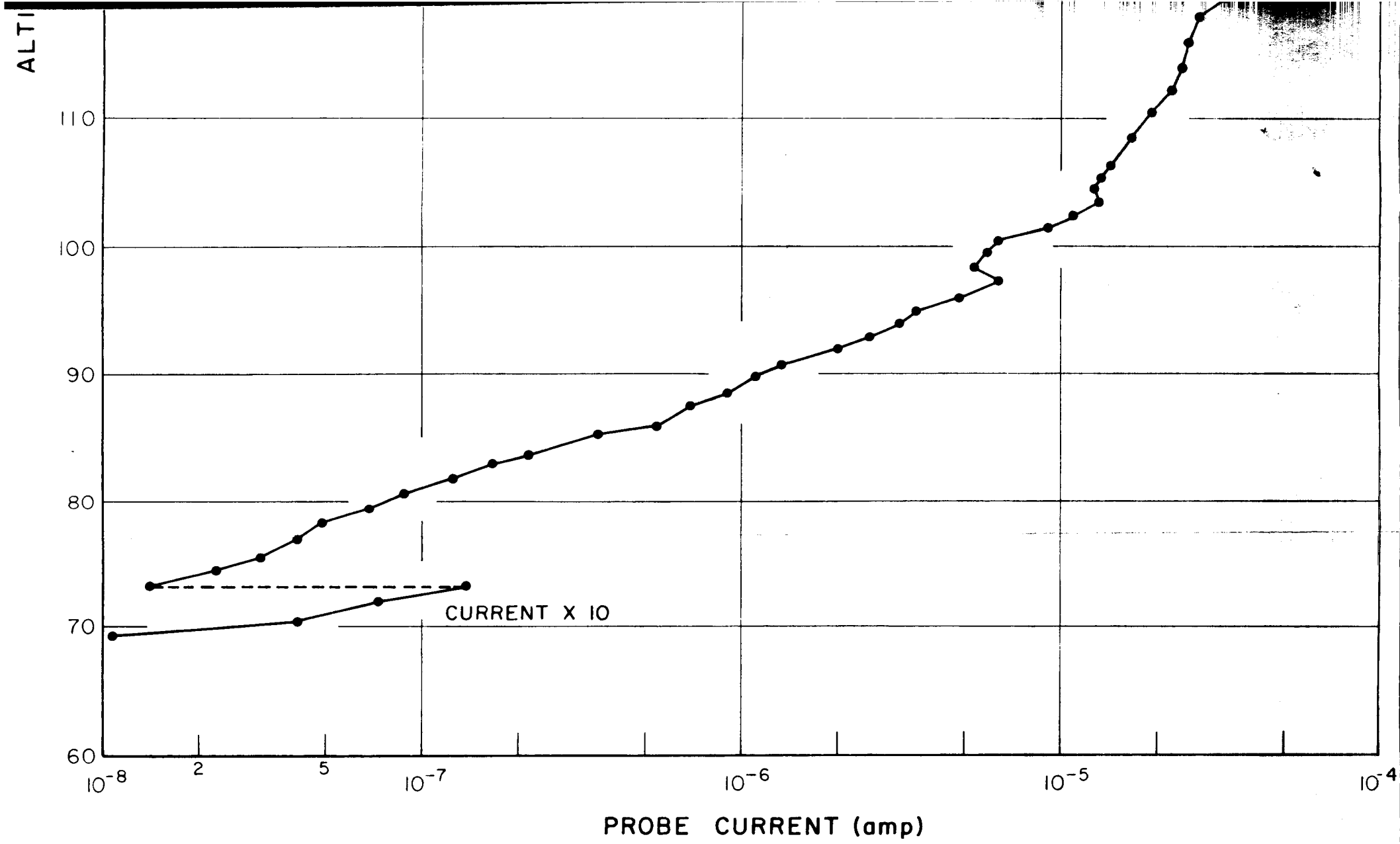


Figure 2

Electron density profile from Nike Apache 14.197.

EFFECT OF ALKALI-VAPOR ON THE PROBE MEASUREMENTS

The ignition of the alkali-thermite mixture immediately results in saturation of the probe signal as seen in the flights of Nike Apaches 14.194 and 14.197.* This is believed to result from deposition of a metallic film (sodium) over the ceramic insulator of the nose electrode assembly. Simultaneously a decrease in the telemetry signal strength is shown by the AGC record. This is attributed to deposition of metal on the insulators of the antennas. The telemetry signal becomes weaker and finally is lost 47 seconds after the alkali-vapor release. A section of the telemetry record of 14.194 from the vapor release to the loss of signal is shown in Figure 3.

On both flights the telemetry signal was re-acquired near the end of the flight--155 seconds after canister ignition for Nike Apache 14.194 and 122 seconds for Nike Apache 14.197. This recovery preceeds the end of the burning (about 180 seconds after ignition) of the mixture in the canister. The altitude of Nike Apache 14.194 was 80 km when the signal was first detected. The telemetry record was not completely clean for this last part of the flight, but was sufficient to show the vehicle attitude and the baroswitch actuation at 75,000 feet (23 km). When the telemetry signal reappears the probe current is already reduced to a small value.

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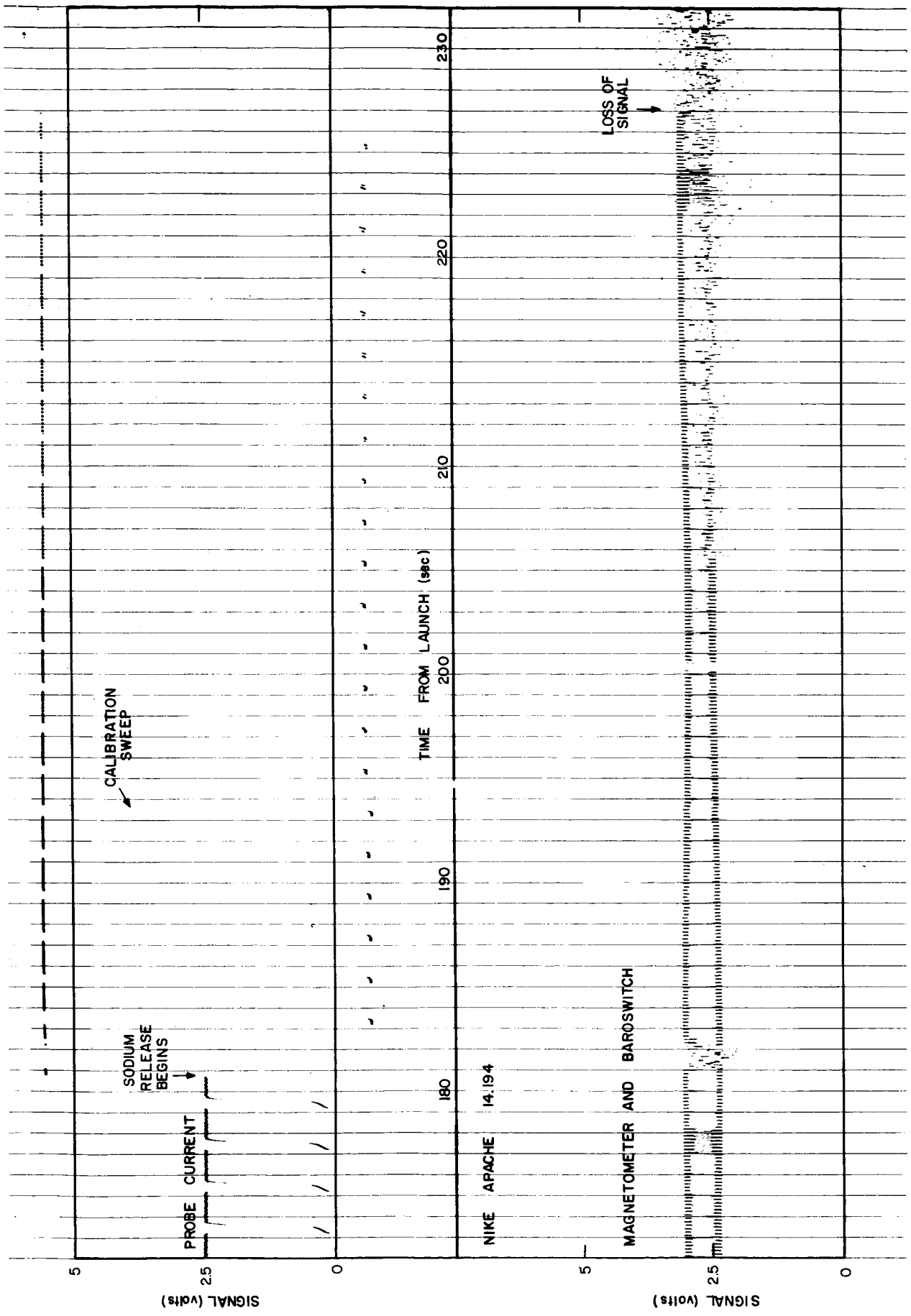
* The canister ignition times on these flights were T+180 sec and T+253 sec, and the launch sites Wallops Island and Fort Churchill, respectively.



Section of telemetry record from Nike Apache 14.194

Figure 3.

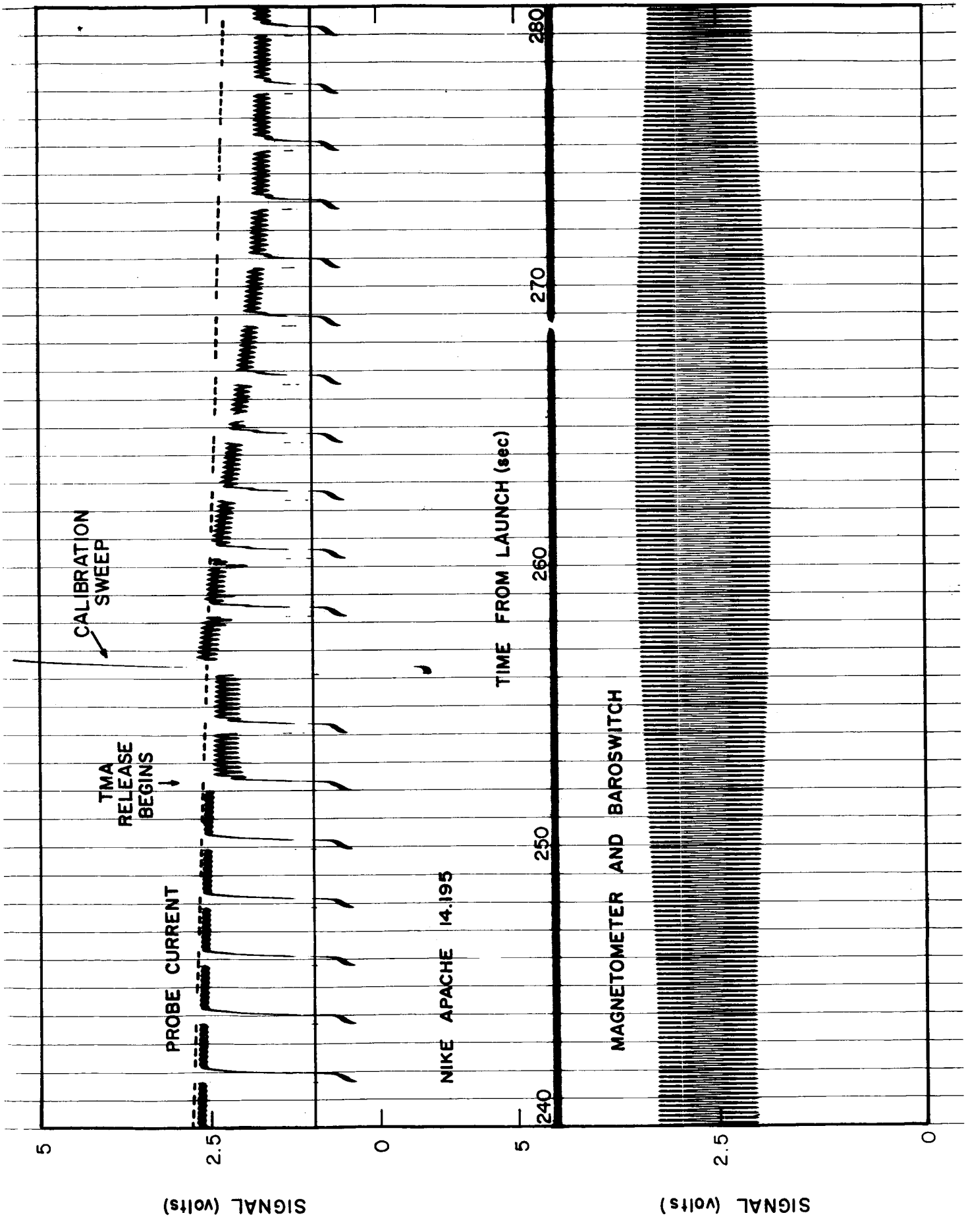
It is inferred that the aerodynamic heating of the surface of the insulators, both in the probe assembly and the antennas, is sufficient to cause the evaporation of the metallic film which had been deposited on them.

EFFECT OF TMA RELEASE ON THE PROBE MEASUREMENTS

A section of the telemetry record for Nike Apache 14.195 between T+240 and T+280 sec, Figure 4, shows the marked effect of the TMA release on the probe current. In this record the dashed line shows the probe current in the same altitude interval (168 to 150 km) on ascent. The other telemetry channel shows the combined signal of the transverse (spin) magnetometer and baroswitch.

Prior to the TMA release at T+251 sec the probe current shows a small spin modulation having an excursion of $\pm$ 0.15 x 10^{-7} amp about the mean current of 6.0 x 10^{-7} amp. After TMA release the current decreases and the modulation increases. Two seconds after the opening of the valve the mean current is 4.2 x 10^{-7} amp and the excursion is $\pm$ 1.0 x 10^{-7} amp. The probe current is modulated at the same frequency as the vehicle rotation presumably because of the single jet provided for the TMA.

The modulation continues for the duration of the TMA release (nominally 90 seconds). The effect produced by the TMA release suggests that themuch smaller spin modulation before the release may be caused by escape of gas from the payload and expended rocket motor. Spin modulation of the



Section of telemetry from Nike Apache 14.195.

Figure 4.

probe current has been observed on all previous flights using the nose tip electrode although the amplitude of the modulation has shown considerable variation from flight to flight.

The clear appearance of the magnetometer signal shows that none of the variation in the probe signal was due to telemetry interference. In fact, examination of the AGC record from Wallops Island telemetry station shows that no change in signal strength resulted from the release of TMA.

The relatively large effect of the TMA on the probe current makes it impossible to obtain true values of electron density. However a semi-quantitative indication of the main structural features of the electron density profile can still be obtained. This is valuable in the application of the combined payload where the horizontal separation of the electron density measurement on ascent from the wind measurement on descent may be 50 to 100 km. This factor and the absence of the telemetry blackout make the TMA preferable to the alkali-vapor for this program. The smaller weight of the TMA/probe payload (69 lb)* over that of the alkali-vapor/probe payload (86 lb)* is another advantage in favor of TMA.

PROJECT STATUS

At the end of the Quarter, preparations had been started for the second of the two field trips to Fort Churchill. The objective is identical with that of the first trip. It is planned to launch four rockets in one night, starting at evening twilight and ending at morning twilight. The launches are now scheduled for the night of 22-23 February 1965, and in

*The probe section of each payload weighs $32\frac{1}{2}$ lb.

the event of unfavorable weather will be rescheduled daily. We have made arrangements to cooperate with W. G. Fastie, John Hopkins University, in obtaining spectrophotometric data on the trails in an attempt to determine the ambient atmospheric temperature.

It has been proposed to increase the scope of the contract to include a third field trip to Fort Churchill in the late Spring or Summer. This is to provide a second opportunity to launch four vehicles in one night and essentially replaces the abortive attempt of November 1964 which failed because of poor weather. Since one payload (Nike Apache 14.197) was expended on that field trip it is also proposed to build a replacement so that four vehicles can be launched on this additional field trip.

The hours of the personnel engaged on this project for the period (1 November 1964-31 January 1965) are:

L. G. Smith, Project Manager	119 hours
J. F. Bedinger, Project Manager	68 hours
N. J. Guarino, Project Engineer	14 hours
S. A. Sapuppo, Engineer	32 hours
A. Corman, Engineer	349 hours
T. Trovato, Engineer	83 hours
W. Aman, Engineer	13 hours

W. Burke, Engineer		130 hours
E. Yavner, Engineer		24 hours
J. Campos, Scientist		264 hours
	Camera operators and technicians	2,353 hours
	Machinists	374 hours
	Draftsmen	260 hours
	Clerical	126 hours